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Cedar Bluff Reservoir, Trego County, Kansas

National Eutrophication Survey, Corvallis, Oreg

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT
ON
CEDAR BLUFF RESERVOIR
TREGO COUNTY
KANSAS
EPA REGION VII
WORKING PAPER No. 511

WITH THE COOPERATION OF THE
KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT
AND THE
KANSAS NATIONAL GUARD
MAY, 1977

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to support plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Kansas State Department of Health and Environment for professional involvement, to the Kansas National Guard for conducting the tributary sampling phase of the Survey, and to those Kansas wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

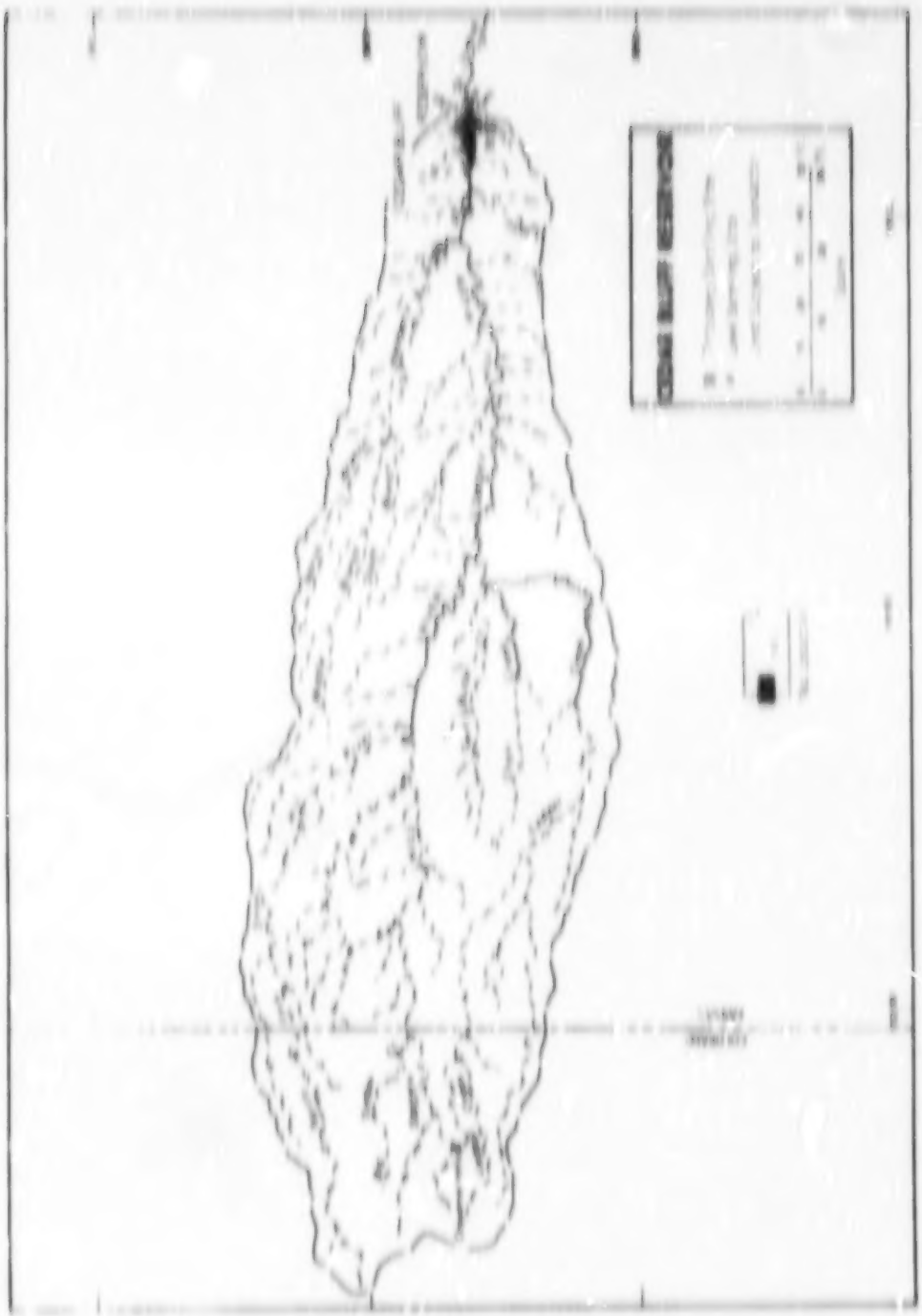
The staff of the Kansas Division of Environmental Health provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General Edward R. Fry, the Adjutant General of Kansas, and Project Officer Colonel Albin L. Lundquist, who directed the volunteer efforts of the Kansas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY
STUDY RESERVOIRS
STATE OF KANSAS

NAME	COUNTY
Cedar Bluff	Trego
Council Grove	Morris
Elk City	Montgomery
Fall River	Greenwood
John Redmond	Coffey, Lyon
Kanopolis	Ellsworth
Marion	Marion
Melvern	Osage
Milford	Clay, Geary
Norton	Norton
Perry	Jefferson
Pomona	Osage
Toronto	Greenwood, Woodson
Tuttle Creek	Marshall, Pottawatomie, Riley
Wilson	Russell

CEDAR BLUFF
RESERVOIR
Scale



CEDAR BLUFF RESERVOIR

STORET NO. 2001

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate Cedar Bluff Reservoir is mesotrophic. It ranked first in overall trophic quality when the 15 Kansas reservoirs sampled in 1974 were compared using a combination of six parameters*. None of the other reservoirs had less median total phosphorus, one had less and one had the same median dissolved orthophosphorus, none had less median inorganic nitrogen, one had less mean chlorophyll a, and none had greater mean Secchi disc transparency. Some depression of dissolved oxygen (to 50% of saturation) occurred at sampling station 2 in June.

Survey limnologists did not observe algal concentrations or aquatic macrophytes and commented on the pleasing appearance of the reservoir in June.

B. Rate-Limiting Nutrient:

The algal assay results indicate Cedar Bluff Reservoir was phosphorus limited at the time the sample was taken (04/15/74).

The reservoir data indicate phosphorus limitation in April but nitrogen limitation in October.

C. Nutrient Controllability:

1. Point sources--No known municipal or industrial wastewater

* See Appendix A.

treatment plants impacted Cedar Bluff Reservoir during the sampling year. Septic tanks serving shoreline dwellings and recreational areas contributed an estimated 0.1% of the total phosphorus load, but a shoreline survey would have to be done to determine the actual significance of those sources.

The apparent phosphorus loading of 0.17 $g/m^2/yr$ is a little more than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as an oligotrophic loading (i.e., a mesotrophic loading; see page 13). However, the level of the reservoir averaged about 4 meters below the conservation pool level during water year 1975 (10/01/74-09/30/75), and the area of the reservoir at that level is not known (Kring, 1977). Obviously, the area was less than the 26.04 square kilometers indicated on page 4; and, therefore, the actual areal phosphorus loading during the sampling year (10/74-09/75) was somewhat greater than 0.17 gm/m^2 but probably was still in the mesotrophic range (i.e., with the phosphorus loading measured during the sampling year, 4,435 kg, the area at minus 4 meters would have to be 41% less than that at the conservation pool level to result in an areal loading just equal to Vollenweider's eutrophic level of 0.28 $g/m^2/yr$).

If the loading is not increased significantly, the existing quality of the reservoir should persist.

2. Non-point sources--Non-point source phosphorus inputs amounted to 99.9% of the total phosphorus load to Cedar Bluff Reservoir during the sampling year. The Smokey Hill River contributed 64.3% of the total, and ungaged tributaries contributed an estimated 24.7%.

The non-point phosphorus export rate of the Smokey Hill River was 0.2 kg/km^2/yr. This rate is very low compared to the rates of Kansas tributaries sampled elsewhere.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS[†]

A. Morphometry[††]:

1. Surface area: 26.84 kilometers^2.

2. Mean depth: 8.5 meters.

3. Maximum depth: 20.0 meters.

4. Volume: 228.272 x 10^6 m^3.

5. Mean hydraulic retention time: 4.5 years (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Smoky Hill River	13,519.0	2.100
Minor tributaries & immediate drainage -	775.1	0.600
Totals	14,294.0	2.700

2. Outlet -

Smoky Hill River	14,322.7**	1.700

C. Precipitation***:

1. Year of sampling: 36.3 centimeters.

2. Mean annual: 59.7 centimeters.

† Table of metric conversions--Appendix B.
†† At conservation pool level; Kring, 1977.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of reservoir.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Cedar Bluff Reservoir was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at two stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration, and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll *a* analysis. The maximum depths sampled were 9.1 meters at station 1 and 10.7 meters at station 2.

The sampling results are presented in full in Appendix B and are summarized in the following table (the June nutrient samples were not properly preserved and were not analyzed).

| | | |

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/15/74	1. Synedra sp.	312
	2. Cyclotella sp.	69
	3. Cryptomonas sp.	35
	4. Oocystis sp.	35
	5. Scenedesmus sp.	35
	Total	486
06/26/74	1. Chroomonas sp.	417
	2. Cryptomonas sp.	38
	3. Carteria sp.	19
	4. Dinobryon sp.	19
	5. Stephanodiscus sp.	19
	Total	532
10/01/74	1. Chroomonas sp.	1,041
	2. Dactylococcopsis sp.	337
	3. Cryptomonas sp.	123
	4. Oocystis sp.	123
	5. Scenedesmus sp.	123
	Other genera	366
	Total	2,113

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
04/15/74	1	12.4
	2	3.6
05/26/74	1	1.5
	2	0.6
10/01/74	1	4.3
	2	2.9

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.005	0.057	0.1
0.050 P	0.055	0.057	1.0
0.050 P + 1.0 N	0.055	1.057	11.5
1.0 N	0.005	1.057	0.1

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Cedar Bluff Reservoir was low at the time the sample was taken (04/15/74). The significant increase in yield with the addition of phosphorus alone and the lack of significant increase when only nitrogen was added indicate that the reservoir was phosphorus limited at that time.

The reservoir data indicate phosphorus limitation in April but nitrogen limitation in October. The mean inorganic nitrogen to orthophosphorus ratios were 14 to 1 in April and 4 to 1 in October.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Kansas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the months of May, June, and July when two samples were collected. Sampling was begun in October, 1974, and was completed in September, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Kansas District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the mean concentrations in Page Creek at station B-1 and the mean annual ZZ flow.

No known wastewater treatment plants impacted Cedar Bluffs Reservoir during the sampling year.

A. Waste Sources:

1. Known municipal - None
2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (non-point load) -		
Smoky Hill River	2,850	64.3
b. Minor tributaries & immediate drainage (non-point load) -	1,095	24.7
c. Known municipal STP's - None	-	-
d. Septic tanks* -	5	0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	485	10.9
Total	4,435	100.0

2. Outputs -

Reservoir outlet - Smoky Hill River 2,090

3. Net annual P accumulation - 2,345 kg.

* Estimate based on 6 shoreline dwellings and 2 campgrounds; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr.	% of total
a. Tributaries (non-point load) -		
Smoky Hill River	92,515	58.7
b. Minor tributaries & immediate drainage (non-point load) -	35,025	22.2
c. Known municipal STP's - None	-	-
d. Septic tanks* -	205	0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	30,000	19.0
Total	157,745	100.0

2. Outputs -

Reservoir outlet - Smoky Hill River 73,875

3. Net annual N accumulation - 83,870 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Smoky Hill River	0.2	6.0

E. Mean Nutrient Concentrations in Ungaged Stream:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Page Creek	0.058	1.851

* Estimate based on 6 shoreline dwellings and 2 campgrounds; see Working Paper No. 175.
** See Working Paper No. 175.

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.17	0.08	5.9	3.1

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Cedar Bluff Reservoir:

"Dangerous" (eutrophic loading)	0.28
"Permissible" (oligotrophic loading)	0.14

V. LITERATURE REVIEWED

Kring, R. Lynn, 1977. Personal communication (reservoir morphometry). KS Dept. of Health & Environment, Topeka.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKING

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN DAPG B	SUM- MER SEC	MEDIAN CHLOR	1- MEAN SD	MEDIAN SECCHI DEPTH M
2801	[illegible] RESERVOIR	0.017	0.005	42,427	4.27	10.400	3.04
2802	COUNCIL GROVE	0.066	0.018	45,625	5.765	11.400	1.425
2803	ELK CITY	0.038	0.010	48,448	3.222	14.000	1.800
2804	FALL RIVER RESERVOIR	0.053	0.470	48,647	7.400	6.200	1.125
2805	JOHN REDMOND RESERVOIR	0.034	0.258	48,467	6.407	6.250	1.250
2806	KANOPOLIS RESERVOIR	0.052	0.040	47,000	34.000	16.250	0.400
2807	[illegible] RESERVOIR	0.052	0.430	48,667	12.400	9.000	0.800
2808	[illegible] RESERVOIR	0.034	0.255	45,333	26.400	14.400	0.667
2809	[illegible] RESERVOIR	0.079	0.720	46,200	26.667	12.000	0.429
2810	[illegible] RESERVOIR	0.022	0.020	46,750	25.200	6.000	0.625
2811	[illegible] RESERVOIR	0.055	0.470	48,571	5.625	13.400	0.917
2812	[illegible] RESERVOIR	0.040	1.240	45,200	6.332	13.750	0.625
2813	[illegible] RESERVOIR	0.067	0.425	48,500	6.000	13.000	0.625
2814	TUTTLE CREEK RESERVOIR	0.042	0.470	48,667	11.278	13.600	0.667
2815	[illegible] RESERVOIR	0.023	0.265	46,222	6.667	13.750	0.364

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]

| | | |

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

[illegible]

[illegible]

[illegible]

[illegible]	SUB-DRAINAGE AREA (SQ MI)	[illegible]					[illegible]							
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

TOTAL DRAINAGE AREA OF LAKE = [illegible]
SUM OF SUB-DRAINAGE AREAS = [illegible]

TOTAL FLOW IN = 32.25
TOTAL FLOW OUT = 28.24

[illegible]

[illegible]	[illegible]	[illegible]	[illegible] FLOW	DAY	[illegible]	DAY	[illegible]	DAY	[illegible]
[illegible]	30	74	[illegible]	13	[illegible]				
	31	74	[illegible]	9	[illegible]				
	32	74	[illegible]	14	[illegible]				
	1	75	[illegible]	12	[illegible]				
	2	75	[illegible]	8	[illegible]				
	3	75	[illegible]	9	[illegible]				
	4	75	[illegible]	13	[illegible]				
	5	75	[illegible]	16	[illegible]	25	[illegible]		
	6	75	[illegible]	15	[illegible]	24	[illegible]		
	7	75	[illegible]	13	[illegible]	27	[illegible]		
	8	75	[illegible]	14	[illegible]				
	9	75	[illegible]	14	[illegible]				
[illegible]	30	74	[illegible]	11	[illegible]				
	31	74	[illegible]	9	[illegible]				
	32	74	[illegible]	14	[illegible]				
	1	75	[illegible]	12	[illegible]				
	2	75	[illegible]	8	[illegible]				
	3	75	[illegible]	9	[illegible]				
	4	75	[illegible]	13	[illegible]				
	5	75	[illegible]	16	[illegible]	25	[illegible]		
	6	75	[illegible]	15	[illegible]	24	[illegible]		
	7	75	[illegible]	13	[illegible]	27	[illegible]		
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	9	75	[illegible]	14	[illegible]				
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	3	75	[illegible]	9	[illegible]				
	4	75	[illegible]	13	[illegible]				
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	6	75	[illegible]	15	[illegible]	24	[illegible]		
	7	75	[illegible]	13	[illegible]	27	[illegible]		
	8	75	[illegible]	14	[illegible]				
	9	75	[illegible]	14	[illegible]				
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	31	74	[illegible]	9	[illegible]				
	32	74	[illegible]	14	[illegible]				
	1	75	[illegible]	12	[illegible]				
	2	75	[illegible]	8	[illegible]				
	3	75	[illegible]	9	[illegible]				
	4	75	[illegible]	13	[illegible]				
	5	75	[illegible]	16	[illegible]	25	[illegible]		
	6	75	[illegible]	15	[illegible]	24	[illegible]		
	7	75	[illegible]	13	[illegible]	27	[illegible]		
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	3	75	[illegible]	9	[illegible]				
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	2	75	[illegible]	8	[illegible]				
	3	75	[illegible]	9	[illegible]				
	4	75	[illegible]	13	[illegible]				
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[illegible]	30	74	[illegible]	11	[illegible]				
	31	74	[illegible]	9	[illegible]				
	32	74	[illegible]	14	[illegible]				
	1	75	[illegible]	12	[illegible]				
	2	75	[illegible]	8	[illegible]				
	3	75	[illegible]	9	[illegible]				
	4	75	[illegible]	13	[illegible]				
	5	75	[illegible]	16	[illegible]	25	[illegible]		
	6	75	[illegible]	15	[illegible]	24	[illegible]		
	7	75	[illegible]	13	[illegible]	27	[illegible]		
	8	75	[illegible]	14	[illegible]				
	9	75	[illegible]	14	[illegible]				

APPENDIX D

PHYSICAL and CHEMICAL DATA

[illegible]

[illegible]

APPENDIX C

TRIBUTARY DATA

[redacted]

[redacted]

[illegible]

[illegible]

[illegible]							
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